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EMISSION INVENTORY OF ENVIRONMENTAL POLLUTANTS

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EMISSION INVENTORY OF ENVIRONMENTAL POLLUTANTS

L.H.J. Wachters

In 1974 a beginning was made in the Netherlands with an inventory of emissions of air and water pollutants and hard-to-process waste products. A description is given of the method of carrying out this inventory, followed by a very brief discussion of the use made of the data obtained.

1. INTRODUCTION

Since the beginning of 1974, TNO has been compiling an inventory of pollutant emissions. Emissions of air pollutants and discharges of waste water are recorded, including quantities and determination of hard-to-process waste products. The inventory includes not only emissions from industry, but also emissions from non-industrial sectors of society, such as traffic, shops, offices, households, agriculture and gardening, and stock-breeding, and does not neglect emissions of natural origin.

The purpose of the inventory is, after processing the collected data, to reach a sound judgement as to the manner and extent of environmental pollution. This understanding should make it possible to achieve a more quantitatively based policy with respect to both combatting pollution and with respect to the establishment of industries and residential areas, laying out of streets, etc.

Naturally, the type and magnitude of many emissions is already known, and for many others it can be relatively simply calculated or estimated. To support the rural environmental policy it is also of importance that the infor-



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form of air pollution emission inventory is underway or in preparation. A program for future years has been set up by the NATO-CCMS* for regular meetings of experts in the field of emission inventorying. And a great deal of attention is to be paid to the use of the information collected for the calculation of air pollution in relation to standard of living.

In what follows we shall discuss the emission inventory as it is being taken in Holland. After a survey of the extent and progress of the project, we shall discuss in succession the system of inventorying, the organization and procedure used, experience gained so far, and finally the use of the data

mation should be gathered together in one place and arranged according to a simply operated system. The very first goal of the emission inventory is accordingly the systematic collection and ordering of the information that is already known or is easily available. Otherwise it is found by measurement.

In other countries too, work is already in progress in various places on the inventorying of emissions. However, this has to do only with emissions of pollutants in the air. In Germany this has been going on in the Ruhr since as early as 1969.* In the USA, the Environmental Protection Agency has for a long time been making an over-all inventory. And from Sweden, Italy, Switzerland, Canada, and Belgium, we hear that one or another

*NATO Committee on the Challenges of Modern Society.

collected in the inventory.

2. EXTENT AND PROGRESS OF THE PROJECT

The initiative for this emission inventory comes from the Ministry for Public Health and Environmental Hygiene (Ministerie van Volksgezondheid en Milieu-hygiëne). As far back as 1972, a preliminary rough plan was set up in consultation with the business community and TNO. And for a considerable length of time the Ministry of Traffic and Waterways (ministerie van Verkeer en Waterstaat) has been involved in the project as well. Since the beginning of 1975, this ministry has also contributed to the financing of the project. Provincial, regional, and municipal services have cooperated intensively in the project.

Broadly speaking, the following steps can be distinguished:

- a. Evaluation of an inventorying system developed in Germany by TUV Rheinland e.V.* for emissions of atmospheric pollutants, i.e.
 - evaluation of the method of storage of emission data and related information,
 - evaluation of the method of collecting these data.
- b. Setting up a plan of procedure for the inventory with proposals for
 - organization
 - approaching the business community and local authorities
 - secrecy,all based on experience gained in Germany.
- c. Adaptation of the system mentioned under a. for use in the Netherlands, i.e. simplification in regard to emissions to be recorded individually, and establishment of a new system for recording emissions which it would be too expensive or pointless to record individually.

* Technische Ueberwachung Verein Rheinland e.V., with its seat at Cologne.

- d. Extension of the inventory system to include discharges of waste water in hard-to-process waste products.
- e. Making a test-inventory in South-Limburg.
- f. Continuing the inventory, taking first the Province of South Holland, then North Holland and Utrecht, and finally the rest of the Netherlands.
- g. Regular updating of information collected.

Of the above steps, a and b were carried out in the spring of 1973. Next, a beginning was made on c and d, adaptation and extension of the German inventorying system. The systems for the individual recording of emissions of air and water pollutants by industry were ready by the beginning of 1974. Then in April 1974 a beginning could be made with the test inventory in South Limburg. This was finished according to plan in December 1974. Then in February 1975 the South Holland inventory was begun, which is expected to continue into the middle of 1976.

The preparation of the requisite computer programs appropriate to the inventory system has unfortunately been somewhat delayed. In the meantime, however, a considerable part of it is ready, so that at least the data on air pollutants can be processed. Also, as a result of a very exhaustive study, the system design for the inventorying of emissions to be registered collectively is now ready. The data already gathered about these emissions for South Limburg and part of South Holland can now be recorded on punchcards.

In order to give an indication of the scope of the inventory, some figures from South Limburg, South Holland, and the entire Netherlands, are presented in Table 1.

From this we see, inter alia, that a very large number of concerns will have to be visited individually. These visits will have to be made by persons who on the one hand are familiar with the type of concern being visited and

TABLE 1. SCOPE OF EMISSION INVENTORY

	S. Limburg	S. Holland	Netherlands
Number of inhabitants	610,000	3,020,000	13,500,000
Area (square km)	690	3,326	41,160
Number of concerns to be inventoried:			
- visit	170	950	3,000
- telephone	-	1900	7,000
Number of atmospheric emissions to be individually recorded	3,500	36,000*	110,000*
Number of waste water emissions to be individually recorded	630	7,500*	30,000*

* Estimate based on the number of concerns in the various branches of industry and on the figures from South Limburg.

the types of emission to be anticipated there, and on the other hand they must be familiar with the prescribed method of inventorying. This last is necessary in order to make the inventory as uniform as possible, for only then will comparison be possible between the various emissions from individual concerns, branches of industry, and types of industry.

3. THE EMISSION INVENTORY SYSTEM

In the inventory a distinction is made between two sorts of emissions:

- A. Emissions requiring individual recording, i.e. such as have their own individual rubric in the data inventory. This is necessary in the case of emissions that cannot be related to generally known statistical data such as number of inhabitants, number of dwellings, number of work-sites, etc.

This includes emissions in the following categories.:

- a. Concerns with emissions peculiar to themselves*, having more than 10

*Emissions characteristic of the concern's activity, excluding emission from gas for heating homes, "household" waste water, and "household" garbage.

employees, and belonging to one of the following classes in the Standard Industrial Classification (SBI-1974) of the Central Statistical Bureau:

- mining
- industry
- public utilities
- some transportation, storage, and communications concerns (cf. B)
- some of the "other services" (cf. B)

b. Concerns with emissions peculiar to themselves but with fewer than 10 employees, but where the emission per concern is relatively great, and statistical treatment is not feasible. This category includes for instance certain heavily polluting chemical and electrical operations.

c. Public sewage systems, pipelines, and sewage purification plants.

B. Emissions calling for collective inventorying, i.e. emissions that are to be summarized in groups. These are emissions that are relatively easy to estimate with the help of statistical data such as population, number of dwellings, number of work-sites, land use, etc.

This category includes emissions from,

- room heaters, cooking appliances in dwellings.
- the use of paint, cleansing agents, spray cans, in dwellings,
- household waste water from dwellings and businesses,
- space heating in businesses (except as included under A),
- operations in types of business where the (small) businesses are more or less uniformly distributed over the population,
- road traffic, rail traffic, shipping,
- agriculture, horticulture, stock-raising,
- natural processes, e.g. pine forests and marshes.

And finally, space has been made in this part of the system for the following types of emissions:

- emissions from large-surface sources such as airfields, railway yards, docks, and similar sources. The last includes also local concentrations of small concerns of types having a non-homogeneous distribution over the population.
- air pollution from abroad. Primarily this is air pollution blown into our country from the countries around us. Also includes marine aerosols and possible other emissions caused by the North Sea.

The method of storage of the data on emissions of the above categories will be considered in more detail below.

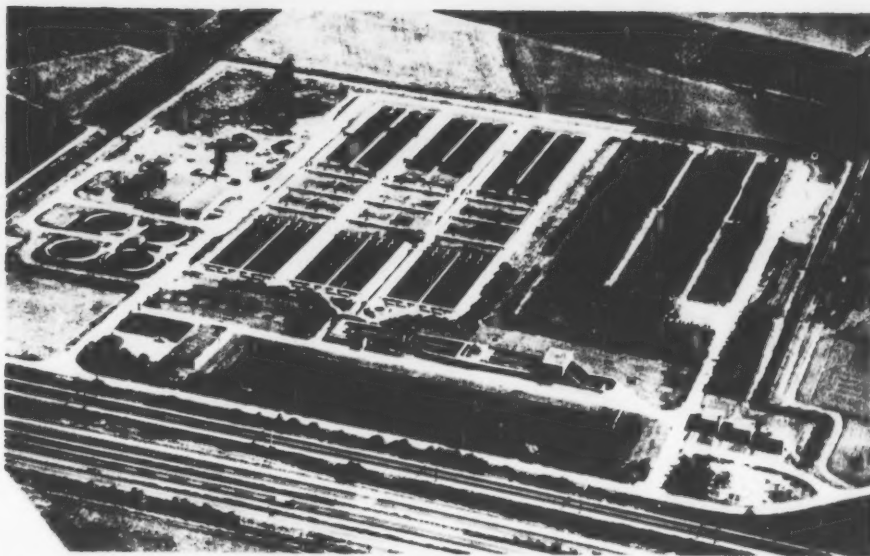
3.1. Individual Inventorying

For the storage of individually inventoried emissions a system is used agreeing in general with that developed in Germany by TUV Rheinland e.V. for atmospheric pollution. First this had to be adapted, on the one hand, on the basis of German experience, and, on the other, to meet certain special requirements of the Netherlands authorities. Then in consultation with experts in the field the system was extended to include waste water emissions. The question was also considered of whether it could also be used for the inventorying of waste substances. In consultation with the Foundation for the Removal of Waste Materials (Stichting Verwijdering Afvalstoffen (SVA) it was, however, concluded that to extend the system by adding a section for waste materials was not very practical, since these could be more easily inventoried by the system already in use by the SVA.

The system for the individual inventorying of air and water pollutants consists of the following seven rubrics:*

1. This rubric contains for every concern the following information: name, address, branch of industry, number of employees, and the authorities responsible for enforcement of the environmental laws.

* A rubric is a range of data to be compared with a tabular survey.



Sewage water purification plant at Breda (Aerophoto Tuege)

2. Substances. For each substance inventoried, this rubric includes the name, chemical composition, as well as a few environmentally relevant characteristics.

3. Installations and apparatus. This covers every installation (=factory) or apparatus causing air or water pollution and gives: name, type, capacity, and location (in coordinates of the National Triangulation Network).

4. Sources, Air. This rubric lists for all sources, i.e. apertures through which emissions can reach the environment (e.g. chimneys, doors and windows of a factory shed): location, height, type, and area.

5. Emissions. Air. This rubric includes first of all references to the above rubrics for the concern responsible for the emission, the substance being emitted, the installation or apparatus that is causing the emission, and the avenue by which the emission reaches the environment. Then follow the amount of the emission, the amount anticipated over a three-year period, an indication of the time during which the emission takes place, the production capacity, and possibly relevant special process conditions during which the emission

takes place, the production capacity, and possibly relevant special process conditions during which the emission takes place, and finally the type and yield of any existing gas purification installation.

6. Sources. Water. This rubric is similar to #4, but with the difference that a distinction is made between sources with direct emissions and sources with indirect emissions. Direct emissions are discharges directly into the surface water, while indirect emissions are emissions into other installations such as sewage systems or sewage water purification installations. In cases of direct discharge into surface water, the name of the body of water is reported, in the case of indirect discharge, the serial numbers (in rubrics 1 and 3) of the concern and installation into which the discharge is made.

7. Emissions. Water. This is entirely analogous to Rubric 5, Emissions, Air.

Waste products that are hard to dispose of are inventoried using a relatively simple system designed by the SVA, in which type and quantity as well as origin and current disposition are recorded.

3.2. Collective Inventorying

Close consultation among experts from the Ministry of Public Health and Environmental Hygiene, the Ministry of Traffic and Waterways, the South Holland Provincial Waterways Administration, and the TNO, has led to the development of a completely new system. In many cases advantage was taken of the suggestions of experts from the State Planning Service, the Central Statistical Bureau, and numerous other agencies. This was necessary since the object was to achieve as simple a system as possible, which could take the information already existing or soon to be available in all possible agencies and use it in calculating the various types of emissions. An attempt was also made to make the system as flexible as possible, so that information available in the future could be included.

The rubrics for storage of data relating to collectively inventoried emissions are as follows:

1. Map Section. This rubric gives, for each map section of one square kilometer of the State Triangulation Network, the number of inhabitants, the number and type of dwellings, the number of employees in the collectively inventoried concerns, the type of local traffic, and the presence of various terrain-connected causes of emission and an indication of the proportion of land surface involved. It also indicates the municipality and the drainage-area containing the major part of the section. On the basis of this and of the data under emission factors (see point 5 below) it becomes possible to calculate the emissions in every map section resulting from space heating in dwellings and businesses, the use of paint and the like, commercial activities in small concerns, local traffic, agriculture and horticulture, stock-breeding and natural processes.

2. Linear Sources. This covers data for the calculation of emissions from traffic on motor roads, waterways, and railroad tracks. For each stretch lying in a given map section the following data are noted: the coordinates of the section, the route number of the road, the length of the stretch, the cause of the emission (e.g., cars or trucks) and the time at which the emission takes place (e.g., only on holidays). Together with data from emission factors (point 5 below) the various emissions from the traffic can now be calculated.

3. Surface Sources. This includes data relating to emissions from airfields, railroad yards, docks, and local concentrations of particular kinds of small concerns.

4. Border data. In every case where the national border falls within a given map section, the following information is recorded: the coordinates of the section, the length of the borderline within the section, and its direction in relation to North. If for a given wind direction the concentration of air pollutants at the border is known (as a function of height above the surface of the earth), then the above data together with a dispersion model permit calculation of the consequences for air pollution in our country.

5. Emission Factors. Here is noted, for each cause of emission, the amount and the type of substances emitted for each emitting agent (e.g. inhabitant, dwelling, motor car).

TABLE 2. CONSULTATIVE COMMITTEES IN THE EMISSION INVENTORY PROJECT

	Policy		Execution	
	Governing Commission	District Auxiliary Commission	Work Consultation Group	Progress Meetings
Dept. of Public Health and Environmental Hygiene:				
Director - Gen. Environ. Hyg.	x			
Chief Inspector " "	x	x	x	x
Regional Inspector " "		x		
Department E. and I.(computer)			x	
Dept. Traffic and Waterways:				
State Waterways	x			
Dist. Director, State Waterways		x		
Govt. Institute Waste Water Purif.			x	
Provinces, Municipalities, Drainage Areas:				
Deputy from Environment	x			
Provincial Waterways		x	x	x
District Environ. Service				x
Municipal Flood Department				x
Drainage Areas		x		
Business Community	x	x		
TNO:				
TNO Directorate	x			
TNO Project Leader	x*	x	x	x
TNO Section and Team Leaders				x

x* Has no formal seat in this Commission.

4. ORGANIZATION OF THE PROJECT

4.1. Consultative Structure

In view of the large number of concerns and agencies involved in the project provision was made from the very beginning for a good consultative structure. The most important part of this is shown in Table 2. The governing commission, consisting of representatives of the two ministries involved in the project, the provinces, industry, and TNO, functions as a forum in regard to land management aspects of the emission inventory. A District Auxiliary Commission is regularly formed for the province where the inventory is currently being made, and deals with the more regional aspects.

The Work Consultation Group exists at the action level. This is the meeting-ground for the technicians of the surveying and the executive agencies, i.e., the agencies responsible for preservation of the environment and the agencies responsible for collecting and processing the emission data. One of the most important tasks of this group has been the setting-up of the inventory system.

At the monthly progress meetings, representatives of the agencies involved in inventorying the business community discuss the progress of the work and possible modifications in the planning. Questions are also brought up that require a decision from the District Consultative Commission or the Governing Commission. In addition to these progress meetings, there are also regular progress consultations at various levels inside the TNO. Finally, a "Leakage Loss" work group has been set up for the project. This is intended as a forum for specialists from government, TNO, and possibly other agencies, for the collection and evaluation of information about emissions from various types of seals and fittings used in industrial processes such as flanges, shutoff valves, safety-valves. The information collected in this manner is used in the inventory in the form of emission factors, i.e., emission per apparatus or per meter of seal. It is intended to extend the activities in this area soon by setting up an "emission factor" steering committee as well as a number of work groups for the collection and evaluation of data in particular branches of industry or other sources of emissions.

4.2. Collection of Emission Data

Data for the individual inventory are gathered by individually approaching all concerns falling in this category. These concerns receive first of all a preliminary letter from the Chief Inspector of Public Health responsible for supervision of the environment, in which his cooperation is requested. Then the concerns that are more complicated from the environmental point of view are visited by a TNO inventorying team. According to the size and type of the concern, the visit may take from a few hours to a whole year. Environmentally simpler concerns are interviewed by telephone.

In determining emissions, use is made as far as possible of

- figures already known at the concern through measurements (including those made by agencies concerned with administration of environmental laws).
- material balances for factories or sections thereof.
- emission factors obtained by measurement or calculation from similar installations or apparatus.

Where this is not possible, and the amount of the emissions justifies it, measurements are taken. As described in 3.1, for each emission a record is made, not only of the type, amount, time, and location, but also of some information relating to the (production) process causing it, and the manner in which the emission reaches the environment. The purpose of this, in due course, is to obtain some insight into the type and magnitude of emissions in particular types of processes and apparatus.

Individual inventorying in South Limburg occupied seven TNO teams of two experts each for about half a year. For South Holland, the number of teams was extended to 16. For the supervision of these teams, 6 academic-level team leaders are assigned. In addition to the inventorying teams, there are simple measurement teams that can be called on where needful to carry out measurements. The entire project is directed and administered from a local office specially set up for this purpose. In South Limburg, it was at

Maastricht; for the South Holland inventory, it is in Gouda.

Both during the introduction to the concerns and during the actual inventorying, then TNO teams in South Holland are as far as possible accompanied by the local authorities charged with the administration of the Air Pollution Law, or the Public Nuisance Act. These officials also assist in the final checking of the data collected.

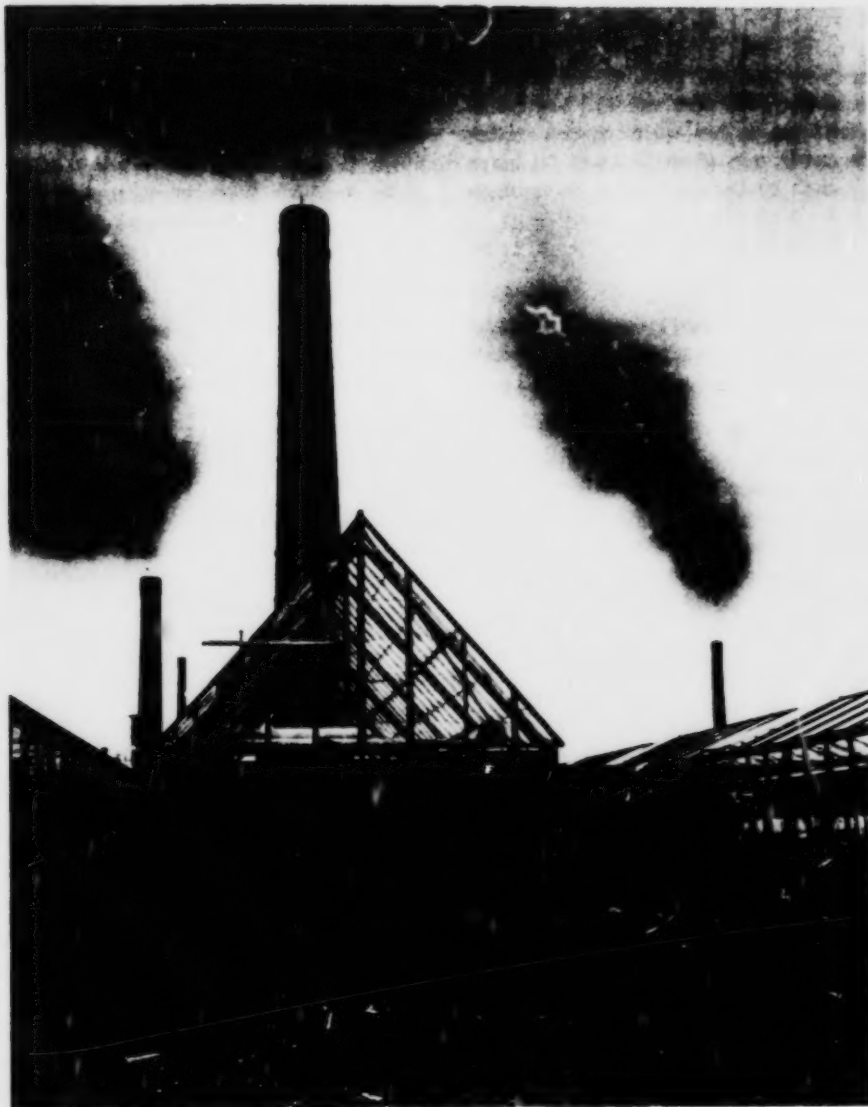
In view of the confidential character of much of the data collected, a great deal of attention has been paid in this project to secrecy. To this end a number of special rules have been established for inventory personnel. In addition, everyone taking part in the project signs a special declaration of secrecy, and there are a number of special regulations with regard to the handling of questionnaires and other confidential material.

The collection of data on emissions to be inventoried collectively is accomplished by a group of varying composition. They have approached a large number of agencies in Holland. The figures on population, number of workers, and the like, are to be made available by the Central Statistical Bureau and the State Planning Service. Figures on land use are obtained from topographical maps, filled in with data obtained from local authorities.

The figures for calculating the various emission factors for collective inventorying derive from a number of studies at home and abroad. It is intended, where necessary and possible, to continue to improve the accuracy of these emission factors through further study.

4.3. Storage of Emission Data

After the information in the questionnaires has been checked, the information on air and water pollution is recorded in the appropriate section of the Ministry of Public Health and Environmental Hygiene on memory discs or magnetic tape. The information obtained in this manner is then checked again, after which the following summary is prepared for each concern where emissions are recorded.



Having greenhouses change over from oil-burning to natural gas may make a serious difference in the battle against air pollution.

- a. Survey of all installations causing air or water pollution giving: registration number, number of similar installations or apparatus, their total nominal capacity, location, name, and year of inventorying.
- b. Survey of all sources, i.e., openings through which air or water pollution leaves the concern, giving registration number, name, location, elevation, surface area (for air pollution sources), disposition (for water pollution sources), and the year of inventorying.
- c. Survey of all emissions grouped by class of substance (gross classification of all compounds), and by compound, and indicating: the registration number of the installation or apparatus causing the emission, the total emission per year, the capacity, and particular process conditions during which the emission takes place, the registration number of the channel through which the emission leaves the concern, the elevation of the channel, the way in which the amount of the emission was determined, and the year of inventorying.
- d. Survey of all emissions grouped by installations: information as in c.

These surveys are sent to the respective concerns, who can then present objections to the correctness of the data. If something seems indeed to be incorrect, they can then be investigated, and, if necessary, changes can be made in the computer records.

The questionnaires dealing with hard-to-process waste products go to the Foundation for the Removal of Waste Materials (SVA) at Amersfoort. A report of the information stored here is also sent to the concern.

Of course the necessary secrecy provisions apply also to the storage and processing of inventory data.

4.4. Experience

With regard to the method of registration, it can be said that experience to date with the modified German inventorying system has been favorable. At present work is being done in consultation with the Ministry of Traffic and Waterways on a slight extension of the system for inventorying public sewage systems, transmission lines, sewage purification installations. The system that has been developed for collective inventorying has been in use for too short a time to permit the drawing of conclusions. Since this system has been largely designed on the basis of available information, problems can hardly be anticipated.

In collecting information from the business community to date, in by far the majority of cases, very good cooperation has been obtained, though in small concerns there was at the beginning a certain reserve toward the inventorying. This is especially true because of the fear of losing a lot of employees' time. When it then becomes clear that this is not going to happen, they then mostly become very cooperative in finding the requisite information, such as process charts, data about apparatus, purchasing data, measurement records.

In some cases it turned out that the announcement of the emission inventory had a salutary effect by itself. On the other hand, in a number of concerns, the actual taking of effective measures represented a very serious step. Reasons for this were:

- the unfavorable economic situation,
- insufficient awareness of the actual amount of emissions,
- insufficient awareness of the dangers of certain emissions,
- insufficient awareness of the technical possibilities of control, and
- lack of awareness of the fact that control may not only mean costs but also profits.

In a number of concerns the results of the TNO inventory team came as a revelation to the management. In general, the impression was gained that

good informational material aimed especially at the smaller concerns could accomplish a great deal.

In collecting data from the non-industrial sector of the community there was excellent cooperation pretty much everywhere. A large number of agencies in the country contribute to this part of the inventorying. Many experts from these agencies have contributed their advice to the setting up of this section of the inventory.

5. THE USE OF THE INFORMATION COLLECTED

As already stated in the introduction, the purpose of the inventory is to gain information in order to reach a sound policy. This policy has to do on the one hand with combatting pollution of the environment, and on the other, the establishment and spreading of industries and residential areas, and the layout of roads. In order to achieve its purpose, surveys must be prepared of the information stored in the various rubrics. Not only surveys of the emissions according to concern will be required, but also according to type of installation, branch of industry, municipality, province, etc. Surveys would also have to be prepared of emissions per map section on the Government Triangulation Network, in order to obtain a picture of the distribution of particular kinds of emissions in a given region. Then diffusion models would have to be used to determine the effect on life conditions of the various air-polluting emissions.

As regards water pollution, one would have to find the burden placed on the surface water by the various emissions. With models of its self-purification capacity, we could perhaps in due time determine what the effects would be on downstream waters. An impression of the situation can be gained by using the emissions already recorded over the last 3 years in the calculations instead of today's emissions.

It will be clear that much of the information collected from the business community is of a somewhat confidential character. Consequently the greatest caution must be observed in regard to publication of the

results of the inventory. These results are after all available to only a limited number of persons. Thus the entire collection of data on air and water pollution will only be available to the Chief Inspector of Public Health in charge of Environmental Hygiene and a few of his inspectors on general service. The data on air and water pollution in a province are also accessible to the Regional Public Health Inspector and the Director and Chief Engineer of Provincial Waterways of the province in question.

The data on air pollution in a province are also available to a number of specified officials in the provincial bureaucracy responsible for Environmental Hygiene. District and Municipal Environment and Public Nuisance Services can only obtain data on concerns that are under their jurisdiction.

The data on water pollution are also available to certain individually specified officials of the National Waterways Commission and the Director of RIZA. The drainage and purification areas have access only to the data relating to concerns under their jurisdiction.

The data on hard-to-process waste materials are available only to the SVA. Naturally all the above-mentioned officials and agencies are obligated to strict secrecy with respect to the data furnished them. There is also an understanding that these data are not to be used in assessing levies.

There are also undertakings with regard to publication of surveys compiled from these data. Thus for the present, publication must be limited to calculated overall emission patterns, and total emissions for modules of not less than 3 by 3 sq. km. This is to make it impossible to deduce the emission data for individual emitters.

6. SOME CONCLUSIONS

On the basis of experience gained so far in the emission inventory project, the following tentative conclusions can be drawn:

- The taking of the emission inventory has so far proceeded without serious difficulties.
- The success of a project such as the present one depends upon a sound consultative structure.
- Because of its integral character, this project is collecting environmental information from a large number of different agencies and specialists. The resulting multiplicity of contacts among these agencies and specialists will undoubtedly help to provide a basis for an integrated environmental policy.

LITERATURE

Erhebung und Kartierungsmassige Dokumentation der
Emissionen luftfremder Stoffe in die Atmosphäre
Schriftenreihe Umweltschutz, Bd. 1.3, Verlag TÜV
Rheinland GmbH, Köln (1971-74)